

Final Report

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"Reflection Grating Array associated with the Reflection Grating Spectrometer developed by the Space Research Organization of the Netherlands for the X-ray Multi-Mirror Mission (XMM)."

The University of California, Berkeley (UCB) served as the Principal Investigator institution for the United States participation in the development of the Reflection Grating Spectrometer (RGS) which included the design, development, fabrication, and testing of the Reflection Grating Assembly (RGA). UCB was assisted in this role by the Lawrence Livermore National Laboratory and Columbia University who provided the primary facilities, materials, services and personnel necessary to complete the development. UC Berkeley's Dr. Steven Kahn provided the technical and scientific oversight for the design, development and testing of the RGA units by monitoring the performance of the units at various stages in their development. Dr. Kahn was also the primary contact with the Space Research Organization of the Netherlands (SRON) and represented the RGA development at all SRON and European Space Agency (ESA) reviews of the RGA status.

In accordance with the contract, the team designed and developed novel optical technology to meet the unique requirements of the RGS. The ESA XMM-Newton Mission carries two identical Reflection Grating Spectrometers (RGS) behind two of its three nested sets of Wolter I type mirrors. The instrument allows high-resolution measurements in the soft X-ray range (6 to 38 angstroms or 2.1 to 0.3 keV) with a maximum effective area of about 140 cm² at 15 angstroms. Its design is optimized for the detection of the K-shell transitions of carbon, nitrogen, oxygen, neon, magnesium, and silicon, as well as the L shell transitions of iron. The RGA itself consists of two units. A structure for each unit was designed to hold up to 220 gratings. In its final configuration, one unit holds 182 gratings and the second hold 181 gratings.

The grating array support structure was designed by the engineering team at LLNL. It was machined from a monolithic billet of vacuum hot-pressed beryllium. Beryllium was selected for the grating support structure for its low mass and good stability over the operational temperature range of 10 – 30 degrees C. The structure was mounted with three flexible kinematic mounts which attach to the mirror support structure.

The mechanically ruled master grating was developed by the Perkin Elmer Corporation under the direction of the XMM/RGA Science Team. Once completed, it was replicated by Hyperfine, Inc onto substrates made by Colorado Precision Instruments. The substrates were machined from silicon carbide blanks, each measuring about 10 by 20 cm (see the illustration provided in J.W. den Herder, et al, which is attached). These large gratings needed to be extremely flat in the dispersion direction to avoid degradation of the resolution, and very thin in order to minimize the obstruction of the direct beam by the gratings. The design for the substrates added five stiffening ribs at the back running in the direction of the X-ray beam. Once the substrates were developed and each tested individually against the design specifications, they were delivered to Hyperfine, Inc. At Hyperfine, the master gratings had been replicated onto several submasters and a development tree was designed to produce the full 440 replicated gratings required for the RGA. As a final step, each replicated grating was covered with a 2000 angstrom layer of gold. Each grating was specifically numbered and underwent a full testing suite with the long beam calibration facility at Columbia University before it was certified for flight. Once accepted for flight, the gratings were precisely aligned in the structure to intercept about half of the light emanating from the telescope. The paper by J.W. den Herder (attached) outlines the alignment process.

Once the integration of the each RGA was completed, each underwent a full complement of testing including vibration, shock, thermal and EMI/EMC. The units were then delivered to SRON where they were accepted following a review by both SRON and ESA personnel in mid-1998. During testing and integration, the RGA team completed the physical modelling of the RGA and collaborated with the Science Operations Center and the Science Survey Consortium in designing and implementing both the pipeline process and the analysis software. We also programmed and simulated the observations for the in-flight calibration, performance verification and guaranteed time observations during this period.

XMM-Newton was launched successfully in December, 1999. The RGS instrument exceeded all performance parameters and has already produced exciting results. The first group of paper published are attached to this report. All have been prepared for a special issue of Astronomy and Astrophysics which will publish an edition dedicated to the first XMM-Newton results.

List of Papers Produced with the Support of this Contract:

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